SENTINEL 2

Mission Performance Centre

SENTINEL 2 RADIOMETRIC CAL/VAL

S. CLERC, B. ALHAMMOUD, B. PFLUG, B. LAFRANCE, M. NEVEU VAN MALLE, J. LOUIS, C. BOUZINAC, L. PESSIOT, R. IANNONE, V. BOCCIA

SENTINEL-2 RADIOMETRIC PERFORMANCE OBJECTIVES

- Sentinel-2 is designed as a <u>quantitative remote sensing</u> mission
  - Create consistent time series of surface reflectance measurements for applications such as:
    - Vegetation monitoring
    - Land cover classification and change detection
    - Etc.
- To achieve this goal we need:
  - Accurate and stable radiometric accuracy at TOA
  - Accurate surface reflectance (BOA) retrieval
    - Based on Sen2cor atmospheric correction processor
    - Production started worldwide end of 2018
    - New evolutions planned in the near future
  - Uncertainty estimates
    - Current provided by the Radiometric Uncertainty Tool at L1C

Agra, Uttar Pradesh

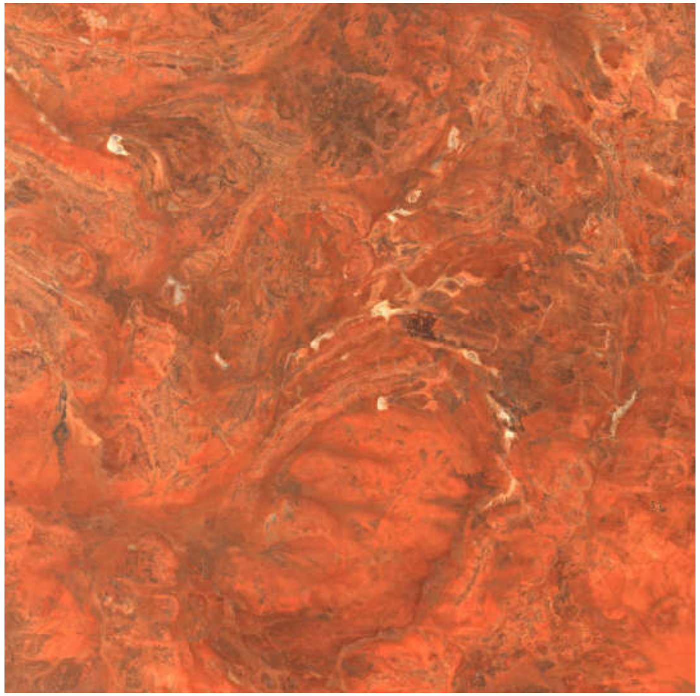
SENTINEL-2 RADIOMETRIC PERFORMANCE OBJECTIVES

➔ L1C (TOA) requirements

- Defined by Mission Requirement Document
- Absolute radiometric accuracy better than 5% (target 3%)
- Stability better than 1%/year
- Inter-band relative accuracy better than 1%

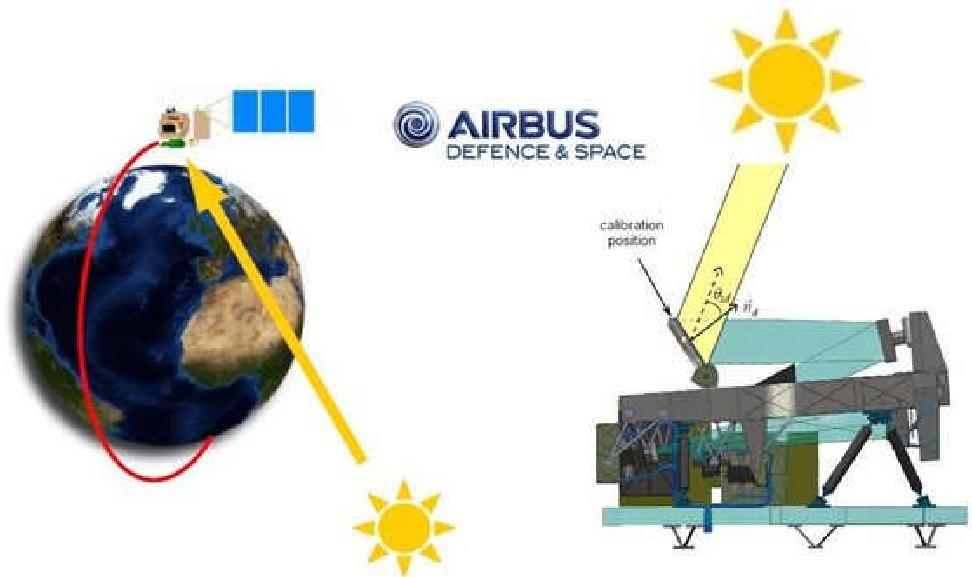
➔ L2A (BOA) requirements

- Target defined by MPC:
- Uncertainty better than 0.05 R_{ref} + 0.005

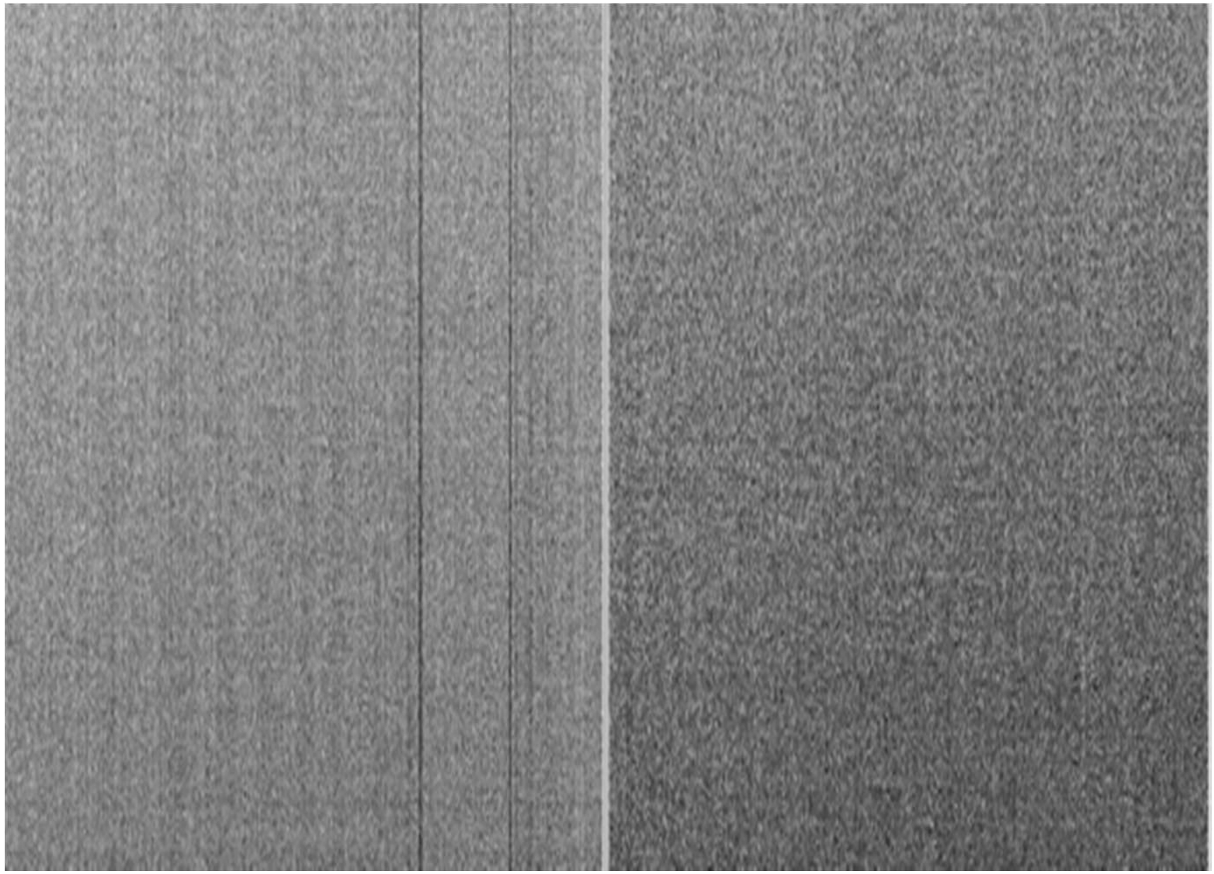


Western Australia

- On-board calibration device
  - White solar diffuser (single unit)
  - Used as reference reflectance for gains adjustment and equalisation (flat-fielding), and to monitor pixel health status
- Dark signal calibration using night-time Ocean acquisitions

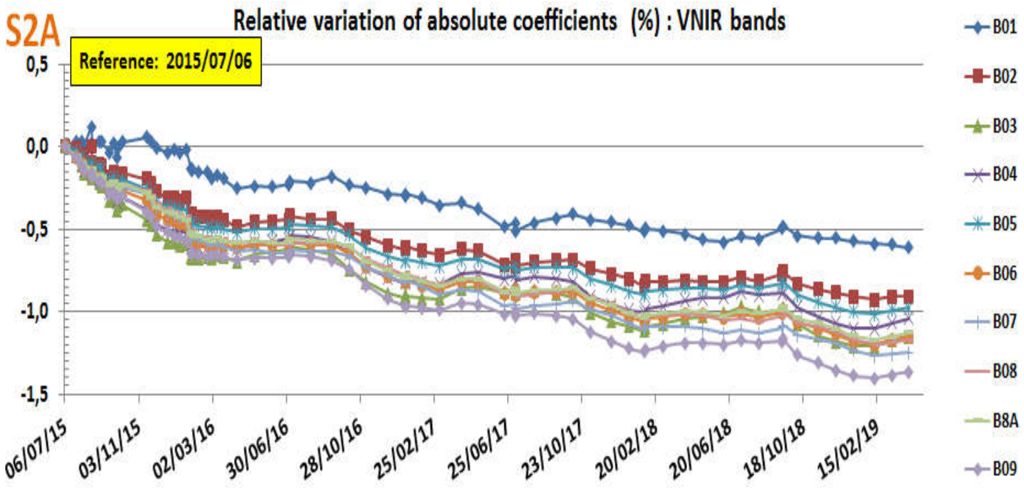


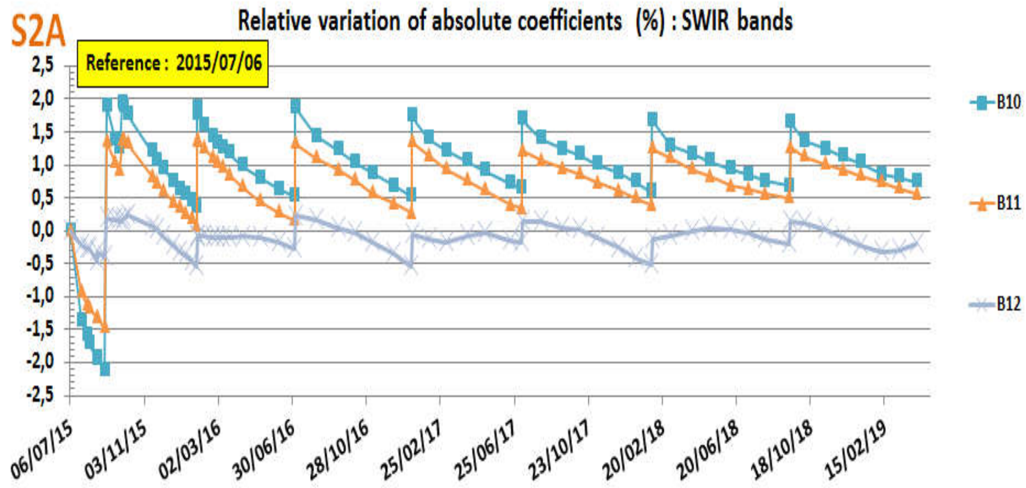
- Radiometric calibration activities led by MPC/CS
- Example diffuser image



Diffuser image: before (left) and after (right) equalization

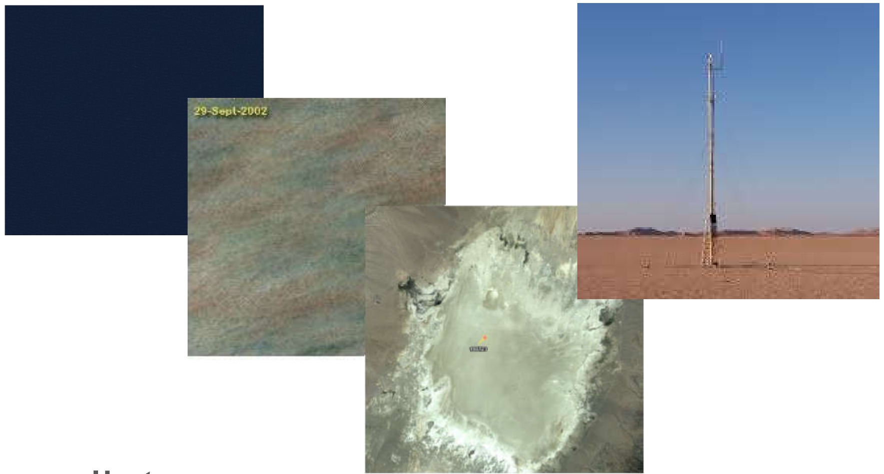
- Calibration operations are performed routinely once per month for Sentinel 2A and 2B
  - Faster degradation of the absolute gains for SWIR bands (B10 & B11) due to ice contamination
- Periodic focal plane decontamination
  - Recovers nominal sensitivity of SWIR bands
  - Periodicity changed from 6 months to one year





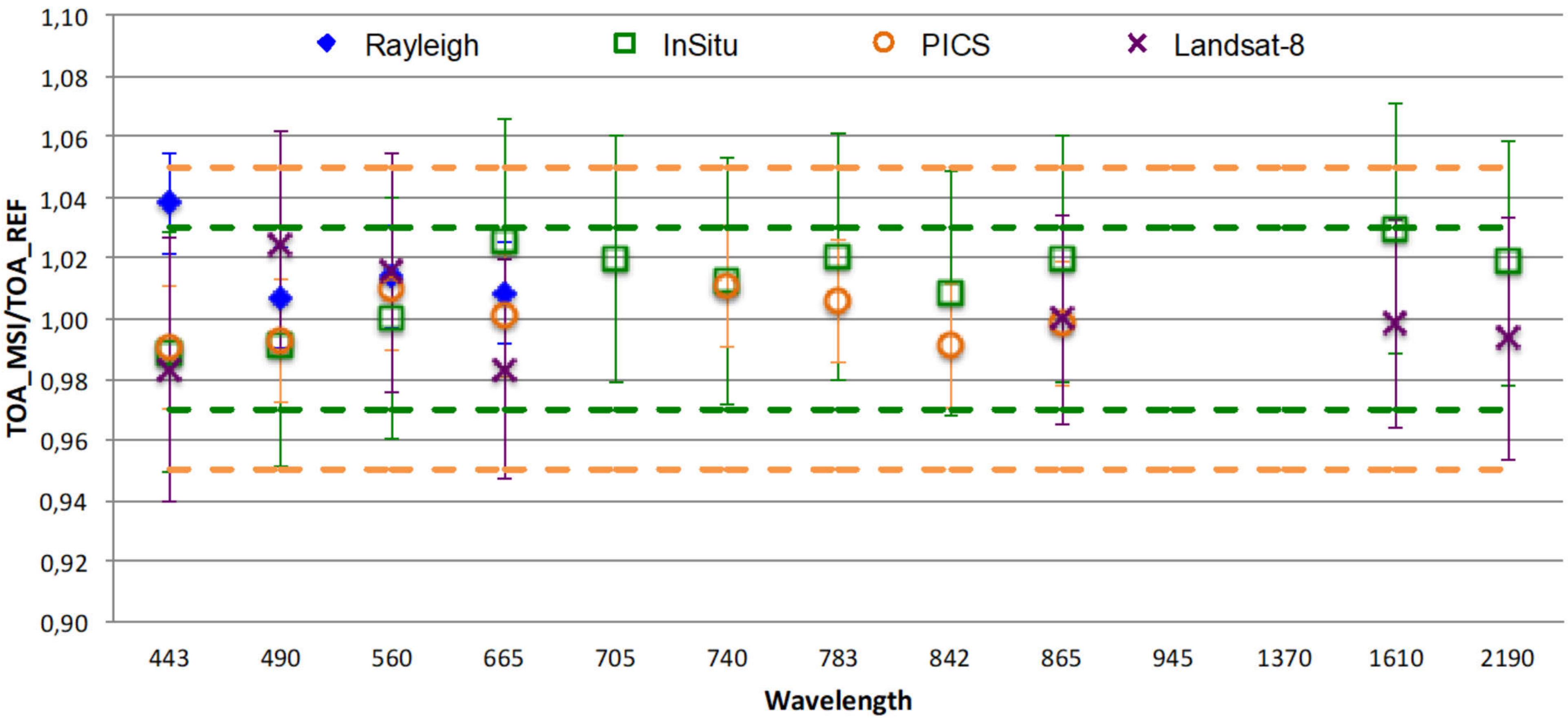
RADIOMETRIC VALIDATION: LEVEL 1C

- Radiometry is continuously monitored using different methods by MPC/ARGANS implemented in DIMITRI software:
  - Rayleigh
  - PICS
  - In-situ (RailRoad Valley data provided by NASA/U. Arizona)
  - Cross-mission comparisons
  - Ad-hoc methods for inter-band: DCC, Sun-glint

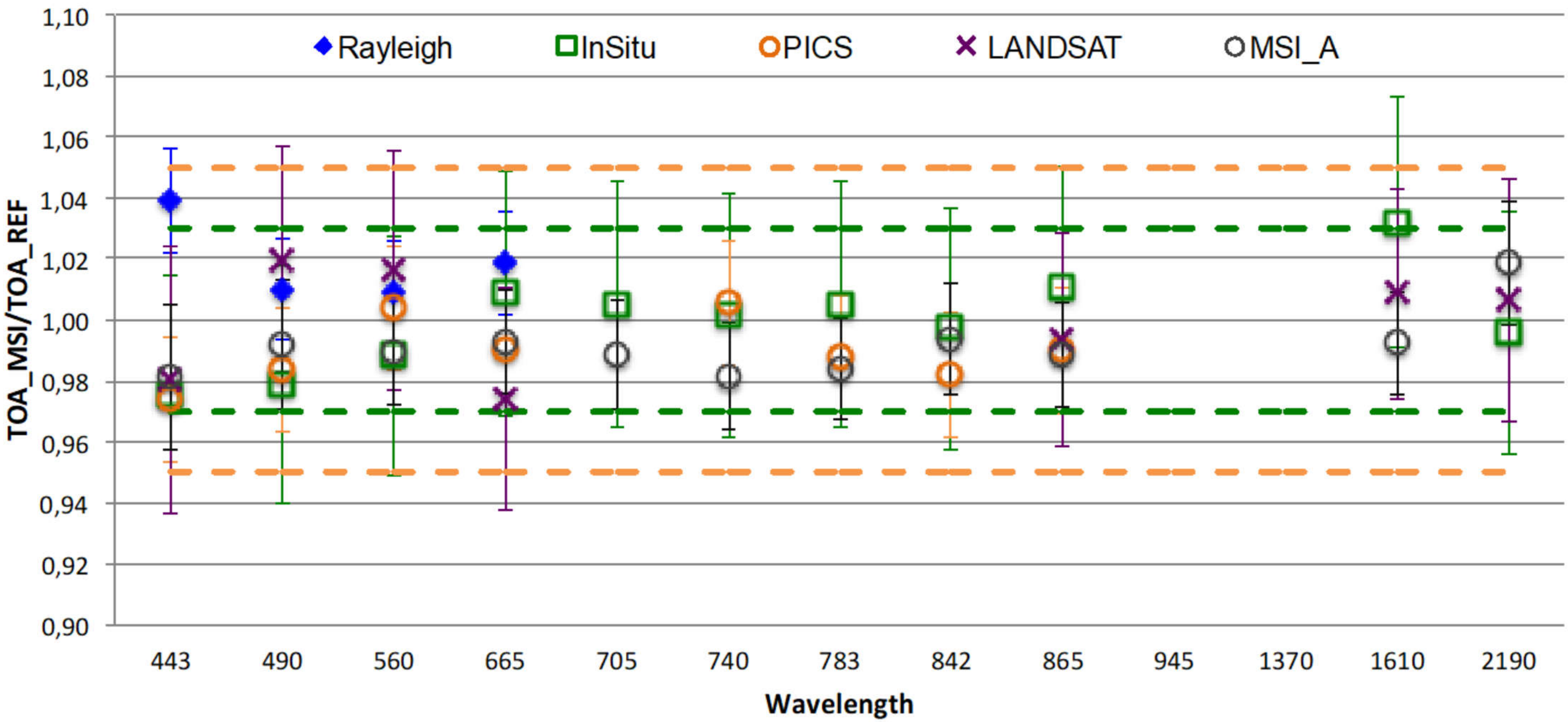


- Estimated performance:
  - S2A and S2B are meeting the requirements (goal value 3%) for all bands
  - Temporal stability is excellent << 1%/year for all bands
  - Inter-band performance better than 1% (TBC)
  - Indication of a small systematic bias between S2A and S2B: ~1% (S2B darker)

➔ Validation results: S2A

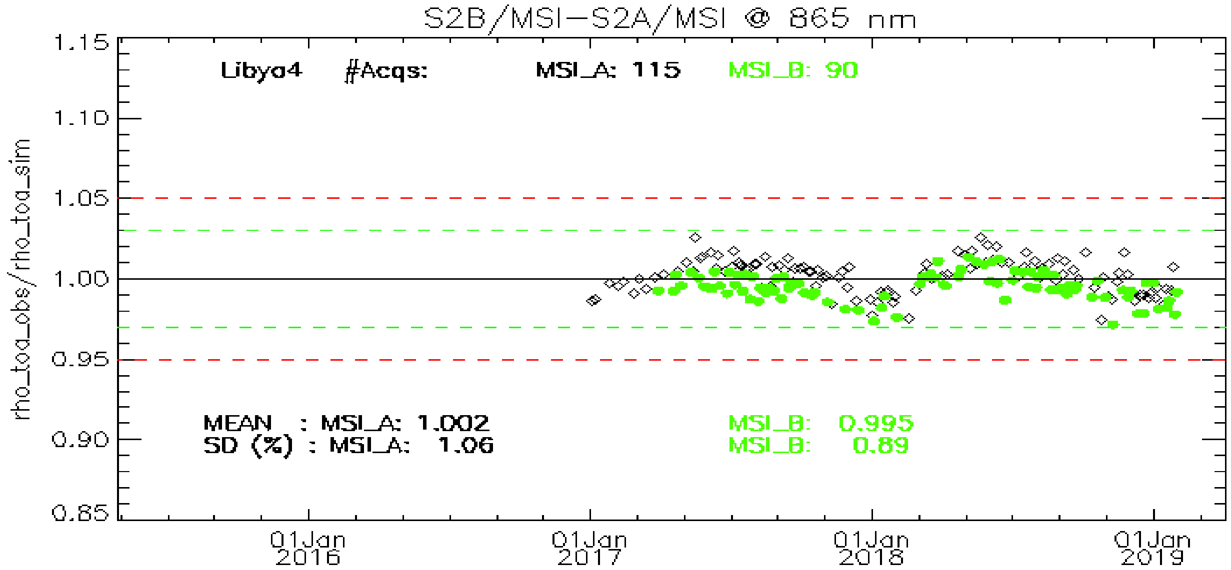


➔ Validation results: S2B

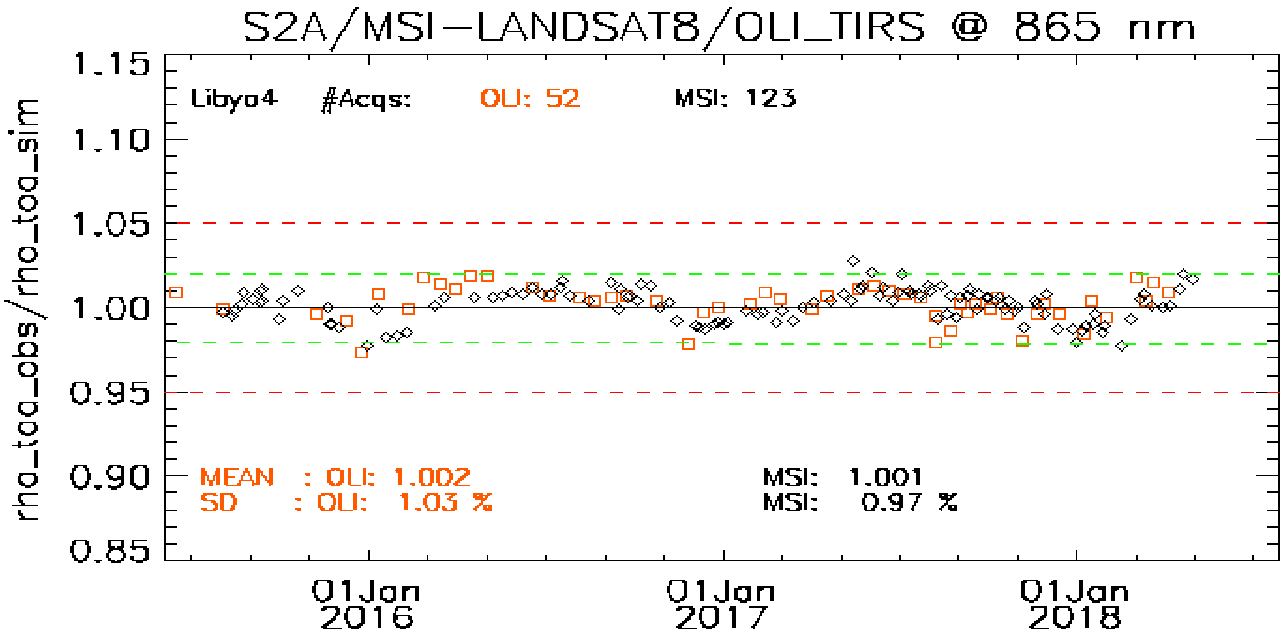


➔ **Desert-PICS** Method: X-mission intercomparison (**LIBYA4**)

MSI-A/MSI-B



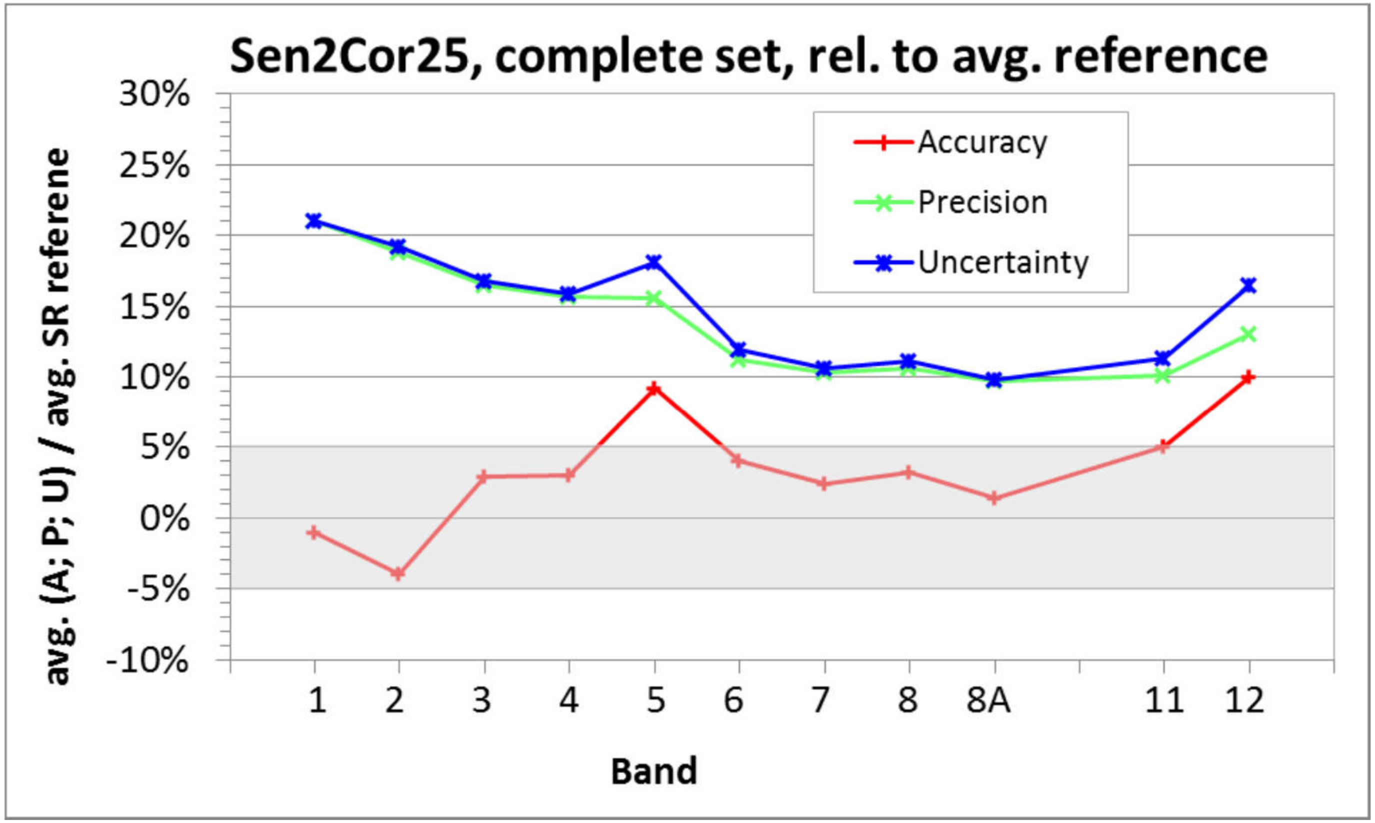
MSI-A/OLI



RADIOMETRIC VALIDATION: LEVEL 2

- ➔ Surface Reflectance Radiometric validation led by MPC/DLR
- ➔ Methods & approaches:
  - “ACIX-like” validation: comparison with 6S inversion using AERONET measurements
  - Ad-hoc ground measurement campaign: Lake Stechlin, May 2018
    - Analysis in progress
- ➔ Performance estimation status
  - ACIX-like approach
    - Accuracy is acceptable but relatively large bias observed
    - Applied on previous version of the L2A processor: update needed (ACIX-2)
    - Poor performance on B05 and B12 bands not confirmed by ground measurements: methodology issue ?
  - Field campaign
    - Good performance both on water and grass
  - Airborne measurements
    - Analysis in progress

- Surface Reflectance Radiometric validation wrt 6S+AERONET reference
  - Accuracy is satisfactory; B05 and B12 degradation not confirmed by other methods
  - Total uncertainty hampered by relatively poor precision



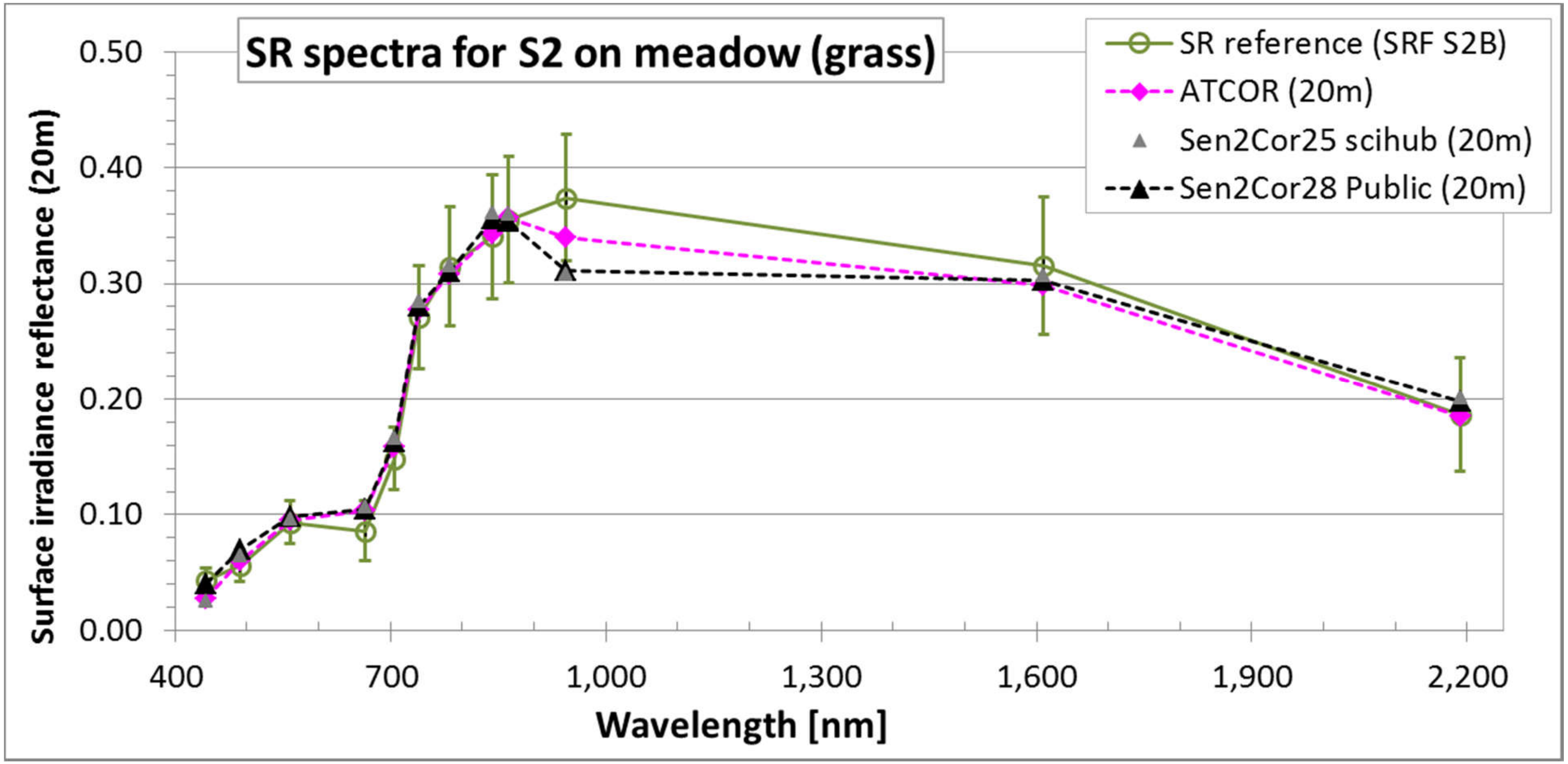
Lake Stetchlin campaign 4th May 2018

› Field campaign + aerial acquisition with HySpex instrument

Landsat 8 over-pass
10:02

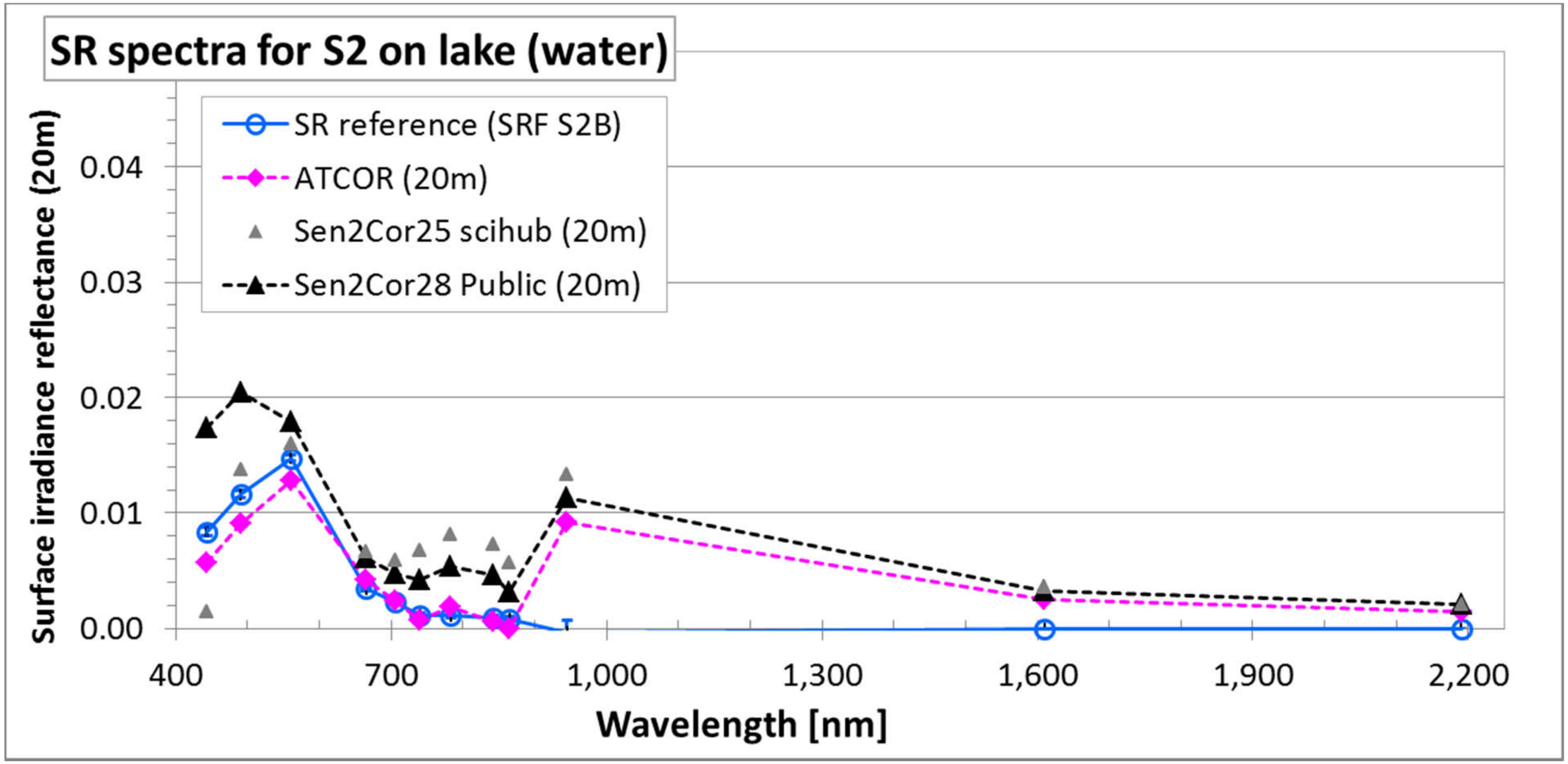
Sentinel-2B over-pass
10:10

➔ Field measurements over meadow (grass)



➔ Good agreement for all bands, except B09 (impact of water vapour)

➔ Field measurements over lake (water)



➔ Good agreement for all bands, except B09 (impact of water vapour)

➔ Spectral shape is less well captured

➔ Differences between processors due in part to processing options

➔ Sentinel-2 Radiometric Calibration and Validation status

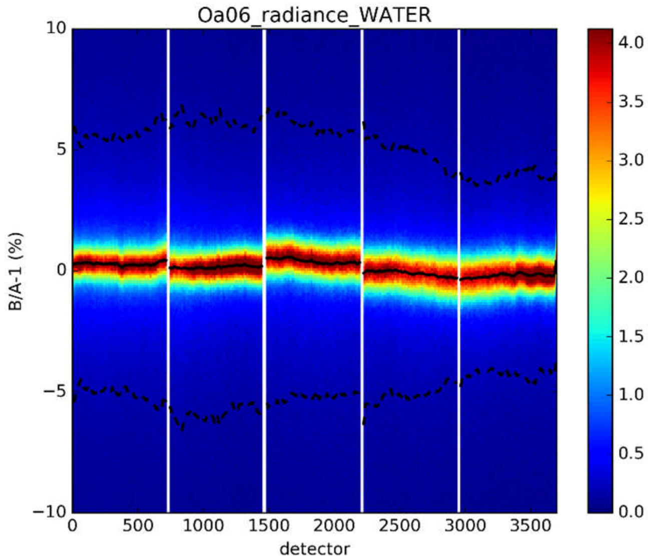
- The radiometric performance of Sentinel-2 is excellent, in terms of accuracy, uniformity and stability
- Sentinel-2 has become a reliable reference sensor in the VIS/NIR/SWIR range

➔ Can we go further ?

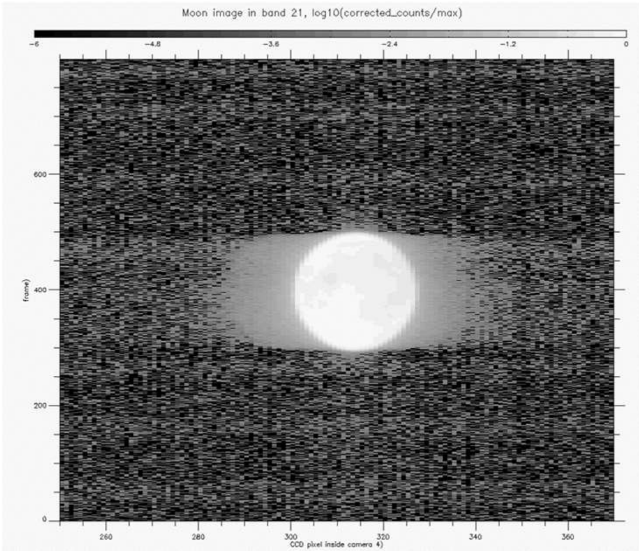
- Perspectives and lessons learned….

Chamdo City, Tibet

- A systematic difference of ~1% is observed between S2A and S2B
  - Difficult to measure this bias accurately using conventional validation methods
  - Sentinel-3 Tandem showed that an inter-calibration with better than 0.5% accuracy is possible
- Comparison with other satellites limited by spectral adjustment and atmospheric effects
  - Sentinel-2 is a broad-band sensor with irregular SRF: limits accuracy of inter-comparison
  - Look for “white” targets and limit atmosphere effects (Moon, FLARE mirrors, Deep Convective clouds…)
  - “Transfer” reference sensor (TRUTHS, CLARREO…)



S3 OLCI inter-calibration



S3 OLCI Moon acquisition (before straylight corr.)

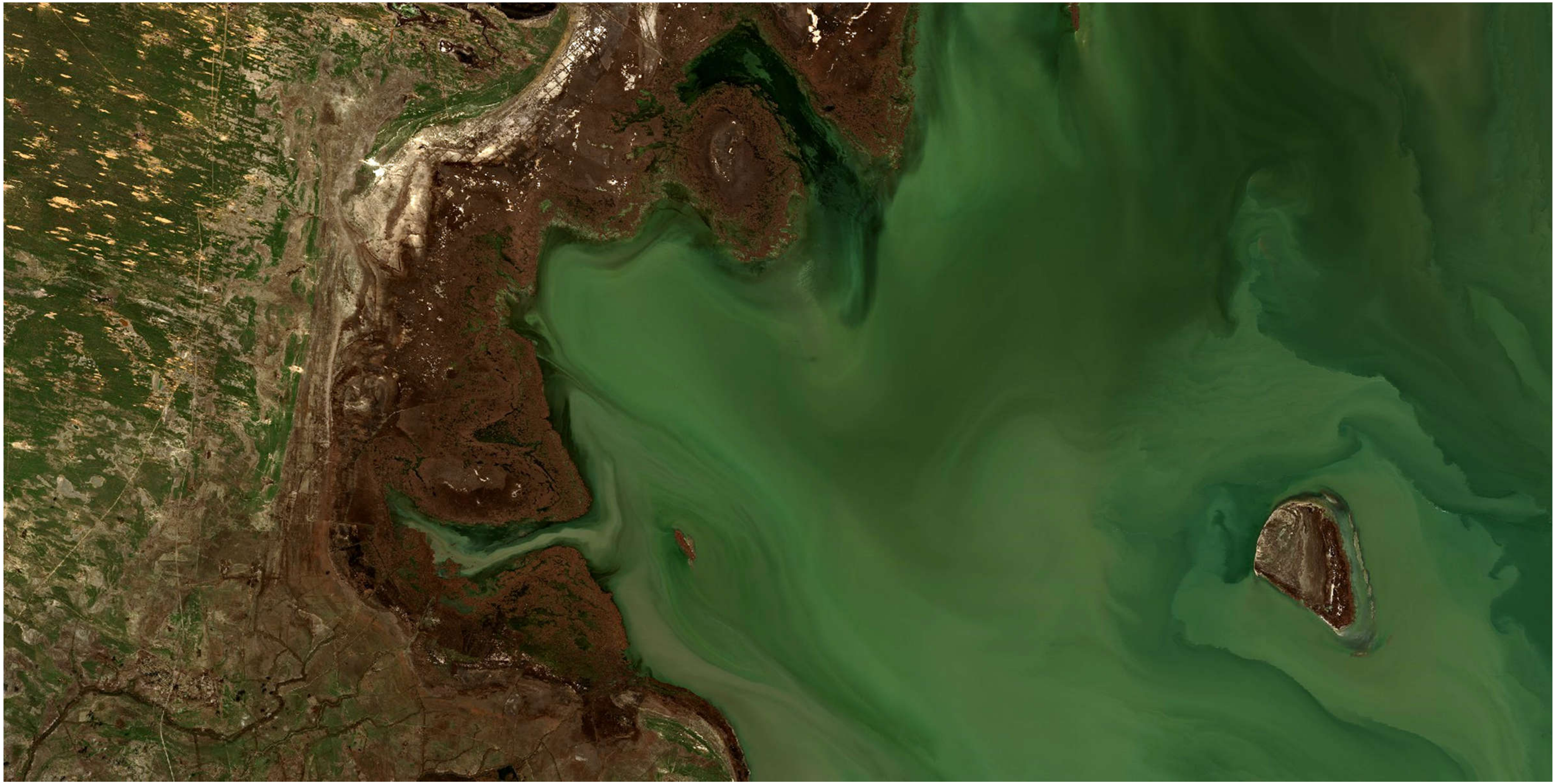
Conclusion and Outlook

- Atmospheric correction is very sensitive to physical modelling and spectral sampling
  - Reference software (e.g. E-Radiate project)
  - Benchmarking exercises (ACIX, ACIX-2)

- Dedicated surface reflectance validation measurement sites needed
  - Intermediate step between
    - TOA cal/val sites (such as RadCalNet sites)
    - And land product validation sites (e.g. GBOV, FRM4VEG)
  - Vegetated sites with variable atmospheric conditions, with characterization of the BRDF
  - Related work
    - HYPERNETS project

➔ Questions?

Kizljar, Dagestan



› The RADCATS data are provided by the NASA Landsat Cal/Val Team as part of the ESA expert users effort